

NUCLEAR ENERGY RESEARCH INITIATIVE

The Development and Production of Functionally Graded Composite for Lead-Bismuth Service

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Collaborators: Los Alamos National
Laboratory

Program Area: Advanced Fuel Cycle
Initiative

Project Description

The use of lead and lead-bismuth eutectic as a coolant for advanced lead-cooled fast reactor systems and transmutation designs has been limited by the corrosive nature of the coolant on fuel cladding or structural materials. The existing upper limit of approximately 550°C for operation of these systems is insufficient. One new Fe-Cr-Si alloy system is designed to provide both a protective film over a wide range of oxygen potentials and, at the same time, provide minimal solubility in liquid metals to prevent formation of SiO₂, which may occur in crevices or other oxygen-depleted areas. The Fe-12Cr-2.55Si alloy has demonstrated a resistance to corrosion in Pb/Pb-Bi eutectic that will allow operation of materials at temperatures up to 700°C. Initial testing indicates resistance to stress corrosion cracking degradation in supercritical water systems. The formation of a protective dual oxide (Cr- based/Si-based) layer provides a high degree of protection.

The purpose of this project is to produce a system that meets both the corrosion and structural requirements of liquid Pb and supercritical water systems at temperatures up to 700°C and, at the same time, be suitable for applications in a neutron flux environment. The clad alloy can be fabricated in the form of welding wire that can then be used as an overlay for either an extrusion billet (for tubing/piping/cladding production) or as an overlay for more complex shapes. Functionally graded composites consisting of a corrosion-resistant layer on a structural alloy will be produced in two forms of tubing suitable for either piping or fuel cladding applications. Two structural alloy systems will be used for each product form: (1) quenched and tempered and (2) oxide dispersion strengthened (ODS), which will be fabricated using standard commercial practice. The materials produced will be tested for corrosion and structural properties.

Workscope

The following activities comprise the primary workscope of this project:

- Tubing production including overlay wire production, Q&T-based tubing production and weld overlay application, and ODS tubing production and weld overlay application
- Corrosion and microstructural characterization testing, analysis, and modeling including overlay wire, cladding product, and pipe/tubing product
- Mechanical properties testing